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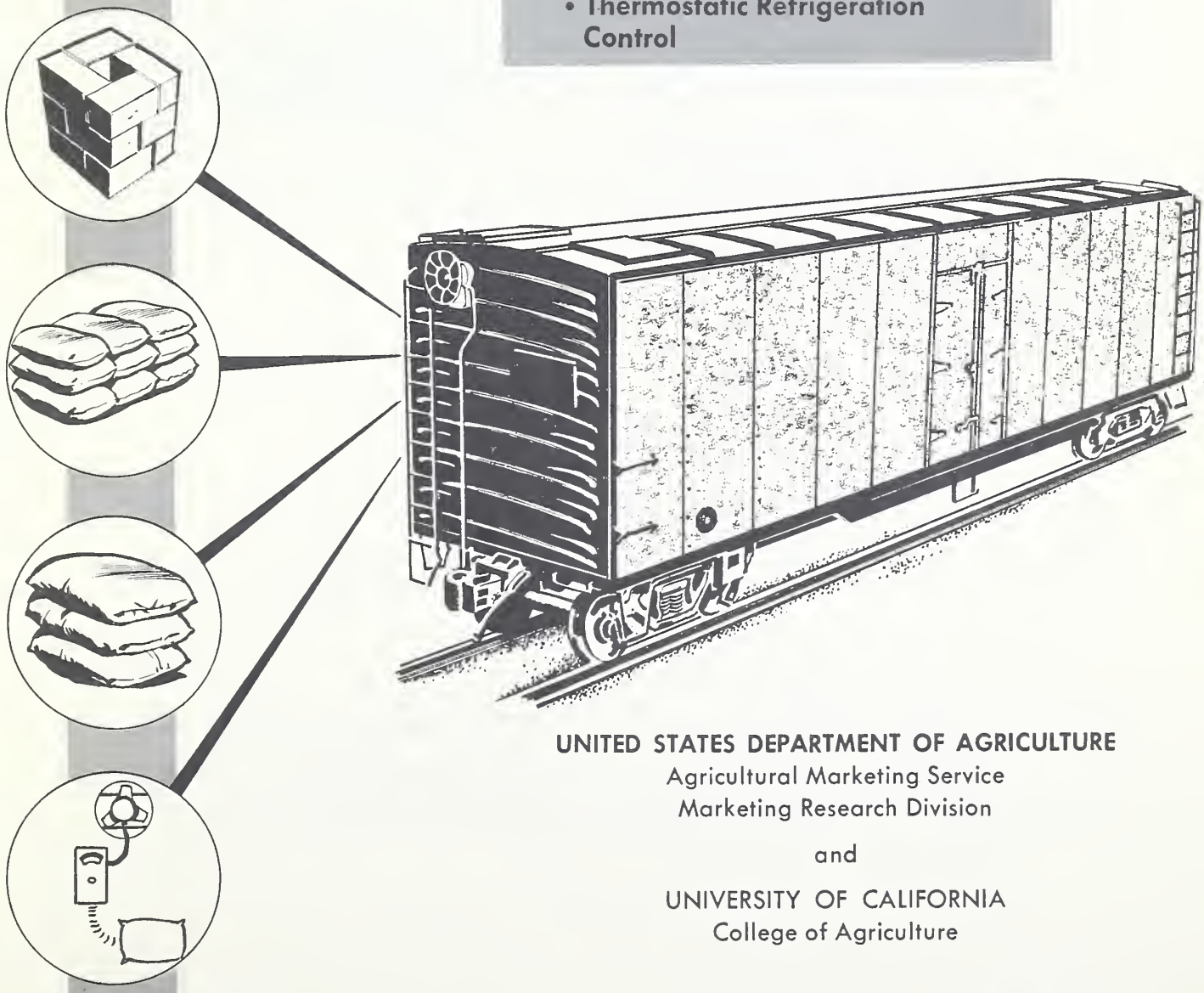
A RAILWAY TRANSPORTATION TEST WITH CALIFORNIA EARLY POTATOES

- Containers
- Icing Practices
- Thermostatic Refrigeration Control



UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division

and

UNIVERSITY OF CALIFORNIA
College of Agriculture

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SUMMARY

Eight cars of early-season White Rose potatoes were shipped from Kern County, Calif., to New York City in a railway transit refrigeration test. The purpose of the test was to study the cooling rate and refrigeration requirements of this commodity when shipped in 50-lb. cartons, 10-lb. paper bags, and 100-lb. burlap bags. Information was obtained concerning a modified icing service for the paper and burlap bags and load patterns for 50-lb. cartons. The effectiveness of experimental equipment designed for the thermostatic control of refrigeration in electric fan cars was evaluated.

The potatoes cooled more slowly in transit in cartons and 10-lb. paper bags than in regular burlap bags, but the difference was of little commercial consequence in this test. As found in previous tests, gradual cooling of skinned potatoes in transit reduced the subsequent surface browning at the market.

Half-stage standard refrigeration provided adequate protection for potatoes in cartons loaded at 80° to 85° F. This service costs about 22 percent less than full-stage standard refrigeration. A modified service, consisting of half-stage initial ice after loading and only two re-icings in transit, was sufficient for potatoes loaded at 70° to 75° and shipped in 10-lb. paper bags. This service, which costs less than half-stage standard refrigeration, was also adequate, in this test, for potatoes in burlap bags loaded at 85°.

The equipment for thermostatic control of refrigeration, when set at 55° F., prevented excessive cooling of the potatoes in transit despite an oversupply of ice in the bunkers.

ACKNOWLEDGMENTS

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Assisting with the test procedure were:

L. L. Morris, J. C. Bishop, F. W. Martin, and L. Rappaport of the University of California; A. L. Ryall and C. F. Pierson, U. S. Department of Agriculture during loading; W. A. Radspinner, J. Kaufman, M. J. Ceponis, L. Rappaport, and C. F. Pierson at destination. Messrs. Morris and Rappaport aided in evaluating and reporting the data.

A RAILWAY TRANSPORTATION TEST WITH CALIFORNIA EARLY POTATOES

Containers, Icing Practices, and Thermostatic Refrigeration Control

By W. R. Barger, horticulturist, Quality Maintenance and Improvement Section, Biological Sciences Branch, Marketing Research Division, and A. A. McKillop, assistant professor, Agricultural Engineering, Department of Agricultural Engineering, University of California

BACKGROUND

Because of skinning and feathering during digging and handling, moderate temperatures during transit are better for early-season White Rose potatoes than low temperatures. Moderate temperatures speed normal healing of the skinned areas and thus protect the potatoes from shrivel and objectionable browning at the market. [1]

Since the 1951 series of transit refrigeration tests with early potatoes from Kern County, Calif., new containers have been introduced which may make changes in refrigeration practice necessary. Also, new equipment is being developed for automatically controlling temperatures in electric fan refrigerator cars during transit.

Therefore, this test was conducted to compare the cooling rates and refrigeration requirements of potatoes shipped in 50-lb. cartons, 10-lb. paper bags, and 100-lb. burlap bags. Information was obtained on the effect of load pattern on the cooling rate of potatoes in 50-lb. cartons. Modified refrigeration was tried for potatoes in 10-lb. paper bags and in regular bags to reduce the cost of the icing service. Thermostatic control of refrigeration in transit was also tested.

PLAN AND PROCEDURE

The test included eight cars of White Rose potatoes loaded the same day and shipped in the same train. Each car represented a different shipping practice, the difference being in the kind of shipping container used, the load pattern, or the refrigeration service (table 1). The cars contained electric and recording thermometers for determining the temperature of the potatoes in transit. They also contained comparable test lots of potatoes so that the effect of the container and protective service on the weight loss and condition of the tubers at the market could be ascertained.

Test Cars

The cars were standard end-bunker ice refrigerator cars, 40 feet long. They were comparable to most cars supplied for potatoes in this district. They had racks for half-stage icing and Preco electric fans for forced circulation of cold air over the top of the load when the cars were moving.

[1] Barger, W. R., Radspinner, W. A., and Morris, L. L. Transportation Test With Early Potatoes From Kern County, California, to New York City, May 1951. U. S. Dept. Agr. H. T. & S. Rept. 271. Apr. 1952.

Cars 5 and 6 contained auxiliary equipment--a thermoswitch and relay and self-closing louvers--for control of refrigeration. The thermoswitch and relay were connected to the fan circuit to control fan operation, and the louvers were installed in front of the fans to prevent convection cooling when the fans were not operating. This equipment was developed by one of the authors, A. A. McKillop, and except for a smaller thermoswitch, is described in "Thermostatic Control of Fans in a Refrigerator Car of Tomatoes."[2]

Containers and Loads

The containers in cars 1 and 2 were 2-piece cartons with full-telescoping tops. They held about 51 pounds of potatoes and the outside dimensions measured approximately 13 3/4 x 17 5/8 x 9 1/2 inches. Two load patterns were used. Car 1 contained a channel-type load in which the cartons were placed crosswise of the car in 5 rows, 5 layers high and 28 stacks long, making a load of 700 cartons with a 2-inch space between rows for air circulation. Car 2 contained a chimney-type load in which the cartons were set alternately crosswise and lengthwise to form hollow squares. The completed load of 720 cartons contained 36 such squares with 4- by 4-inch chimneys up the center for circulation of air.

The containers used in cars 3 and 4 were 10-lb. paper bags with open mesh windows on one side for ventilation and display. The bags in both cars were loaded similarly in 9 rows, 10 layers high and 40 stacks long, totaling 3,600 bags. The bags in the wall rows were set crosswise of the car; all others were placed lengthwise.

Cars 5 to 8, inclusive, contained regular 100-lb. burlap bags loaded crosswise of the car in 3 rows, 5 layers high and 24 stacks long, making loads of 360 bags each. All of the loads were "through" loads; that is, they were continuous from one end of the car to the other, with no bracing at the doorway to take up lengthwise slack.

Both the 10-lb. paper bags and the regular burlap bags were protected on the floor by pads of corrugated fiberboard.

Placement of Thermometers and Thermoswitch

During the loading of the cars, resistance thermometers were inserted in the bottom, middle, and top bags or cartons along the centerline of the car at the bunker, 1/8 length, 1/4 length, and 1/2 length (doorway) positions in the loads. Recording thermometers were placed above the load and under the floor rack in thermostatically controlled cars 5 and 6 and in check car 7 to record air-blast and air-return temperatures.

In cars 5 and 6 the thermoswitch was buried completely in a bag of potatoes located in the top layer of the load near the doorway.

Test Samples

The potatoes examined at the market were taken from a single field lot after the potatoes in the lot had been washed and graded commercially. They were U. S. No. 1, size A, ranging in weight from 5 to 10 ounces. Skinning was mostly moderate but ranged from slight to severe.

The test samples were weighed, packed in the type of container used for the rest of the load in the car, and placed near a resistance thermometer in order to relate condition to transit temperature.

At destination, the potatoes were inspected on arrival and again after holding for a week at 70° F. During the holding period at the market, the potatoes were unpacked and

[2] Barger, W. R., Ryall, A. L., and McKillop, A. A. Thermostatic Control of Fans in a Refrigerator Car of Tomatoes. U. S. Dept. Agr., Agr. Mktg. Serv., AMS-81, 16 pp., illus. March 1956.

held in ventilated crates so that the effect of the transit temperature on subsequent browning could be observed.

Route and Refrigeration

The test cars were routed by Santa Fe Railroad to Chicago and by Pennsylvania Railroad from Chicago to Jersey City. They were loaded at Cawelo, Edison, and Arvin, Calif., on May 18 and forwarded to Bakersfield under standard ventilation with fans turned on. The cars were initially iced on May 19, about 1 p.m., Pacific standard time, at Bakersfield; three thousand pounds of ice was put in each bunker on the half-stage racks. The cars were then forwarded to destination with vents closed and fans on. Cars 3 and 8 were shipped with half-stage initial ice and two re-icings in transit; the other cars all moved under half-stage standard refrigeration.

The cost of half-stage standard refrigeration is about 22 percent less than full-stage standard refrigeration. The half-stage modified service used was $19 less than half-stage standard refrigeration.

The cars left Bakersfield at 3:40 p.m. on Saturday, May 19, and arrived at Jersey City the following Friday at 9 p.m. The cars were opened for inspection and the test samples removed on Sunday night, May 27. The log of the trip appears in table 2.

RESULTS

Transit Temperature

The transit cooling of potatoes in cartons (cars 1 and 2) shipped with half-stage standard refrigeration is shown in figure 1. Compared with the conventional load of

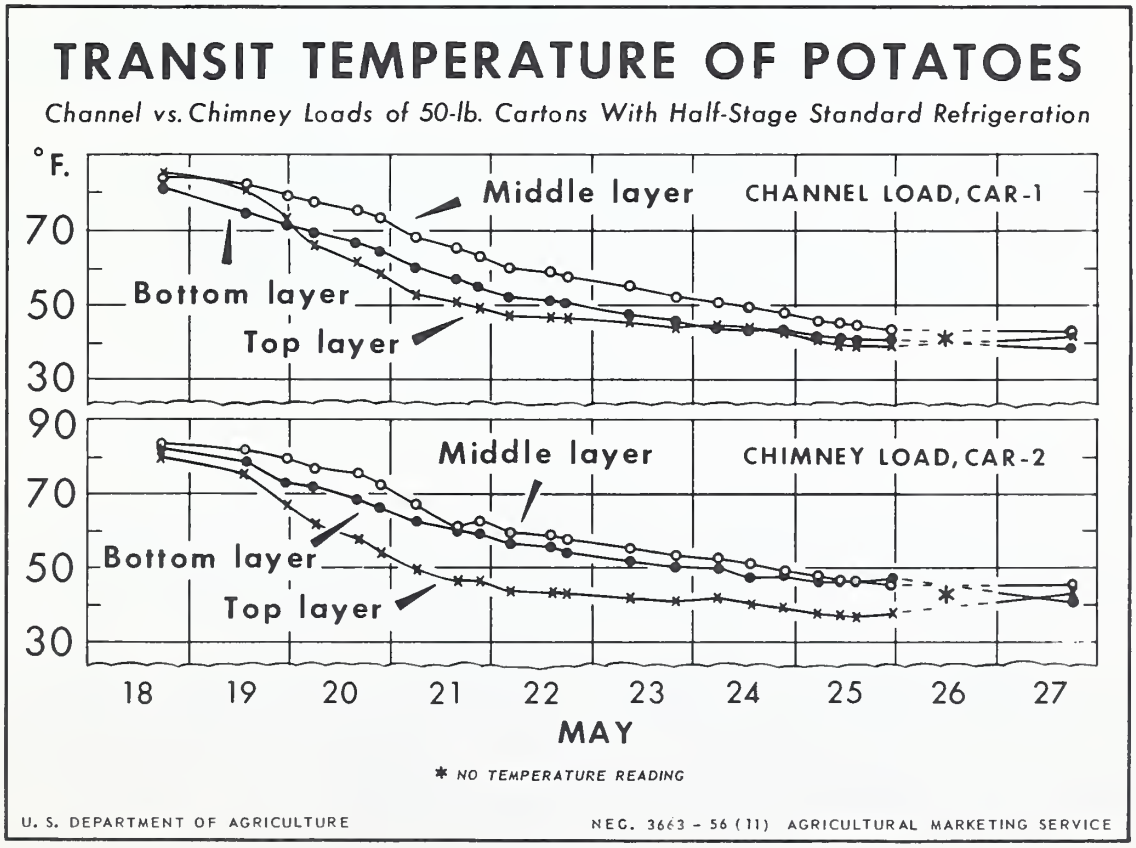

Figure 1.

100-lb. burlap bags under similar icing instructions (car 7, fig. 3), the potatoes cooled much slower in cartons, and the difference in temperature between various positions in the load was much greater than with the bag load. For potatoes shipped in cartons, the channel load resulted in somewhat better distribution of refrigeration than the chimney load, as indicated by the average temperature of the various layers (fig. 1).

The transit cooling of potatoes in cars 3 and 4, containing 10-lb. paper bags, is shown in figure 2. Under half-stage standard refrigeration, the potatoes cooled more slowly in 10-lb. paper bags than they did in regular burlap bags (car 4, fig. 2, and car 7, fig. 3). Temperature difference between layers of the load was greater in the car containing the 10-lb. paper bags.

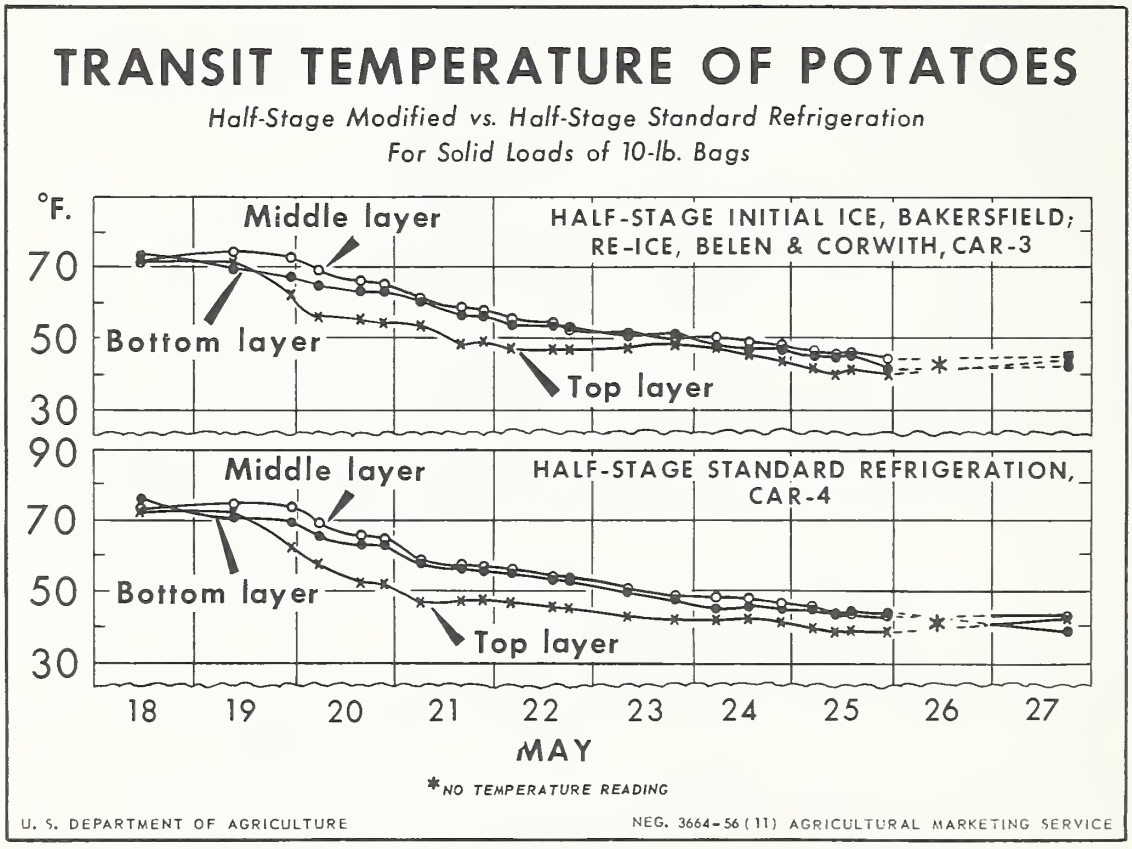

Figure 2.

Cars 3 and 4 were loaded alike, but one was supplied with half-stage initial ice and two re-icings and the other had half-stage standard refrigeration. With potatoes ranging in temperature from 70° to 75° F. at loading, the modified half-stage icing service of car 3 was as effective as the half-stage standard refrigeration of car 4.

The transit temperatures obtained in cars 7 and 8, containing conventional loads of 100-lb. burlap bags, are shown in figure 3. With potato temperatures averaging only 70° F. at loading, half-stage standard refrigeration provided more refrigeration than was necessary or desirable for skinned potatoes (car 7). Although car 8 contained warmer potatoes than car 7, a modified protective service of half-stage initial ice and 2 re-icings in transit provided adequate refrigeration for these potatoes.

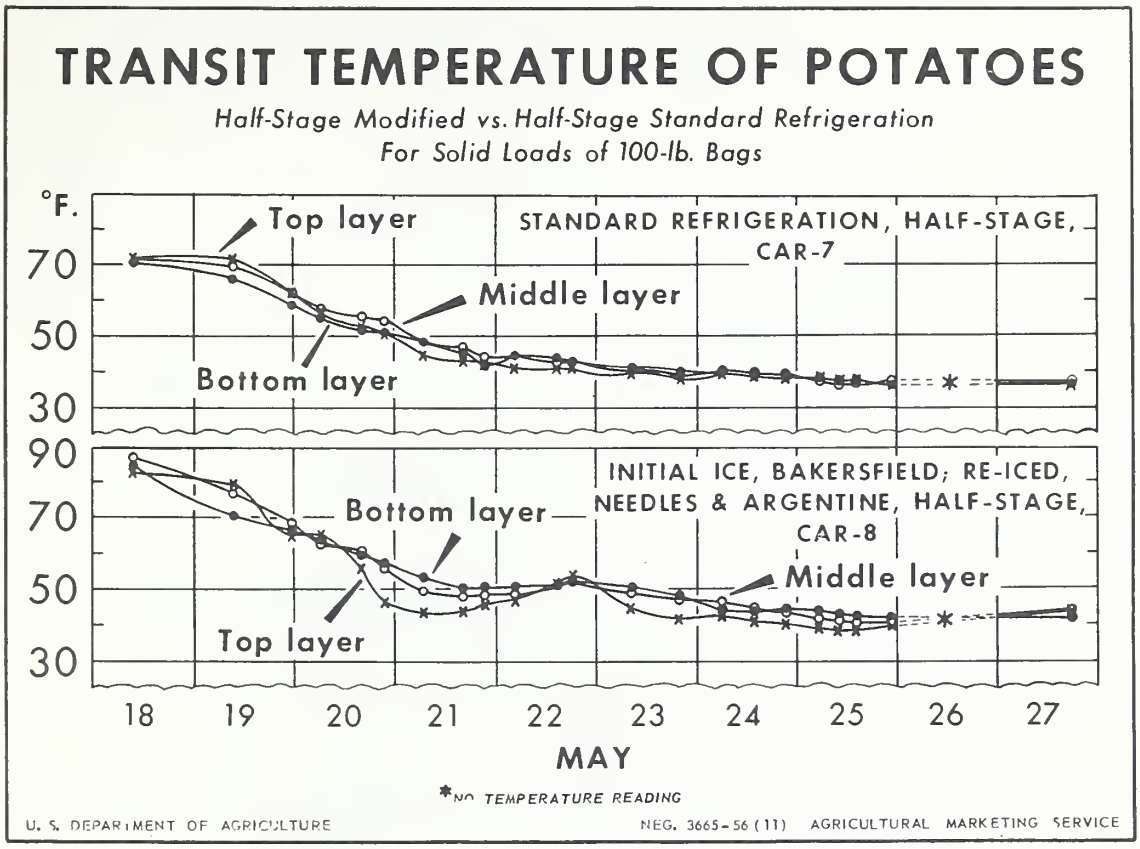

Figure 3.

The effect of thermostatic control of fans and louvers in cars 5 and 6 on the transit temperature of the potatoes is shown in figure 4. Both cars were shipped with half-stage standard refrigeration. In car 5 the thermostat was set at 45°F., and in car 6 it was set at 55°. The temperature of the potatoes, after the initial cooling period, was maintained close to these settings despite an excess of ice in the bunkers at all times. A comparison of the temperatures in car 6, with the thermostat set at 55°, and in car 7, containing no thermostat, shows the moderating effect of the thermostat and louvers on the refrigeration and convection cooling of the potatoes in transit (fig. 5).

Icing Data

Table 3 shows the quantity of ice put in each of the test cars and the estimated quantity remaining at destination. Total ice put in the cars shipped with half-stage standard refrigeration and no thermostatic control (cars 1, 2, 4, and 7) ranged from 21,500 to 22,700 pounds; the quantity of ice melted ranged from 16,300 to 17,500 pounds for these cars. In car 3, supplied with half-stage initial ice and two re-icings, 18,000 pounds was added and about 15,000 pounds of it melted. Under a similar service, nearly all of the 15,600 pounds of ice in car 8 melted in transit. Car 6, with thermostatically controlled refrigeration set for maintaining temperatures at 55°F., melted less ice than any other test car. Ice meltage in this car was greatly reduced after the potatoes were cooled to 55°.

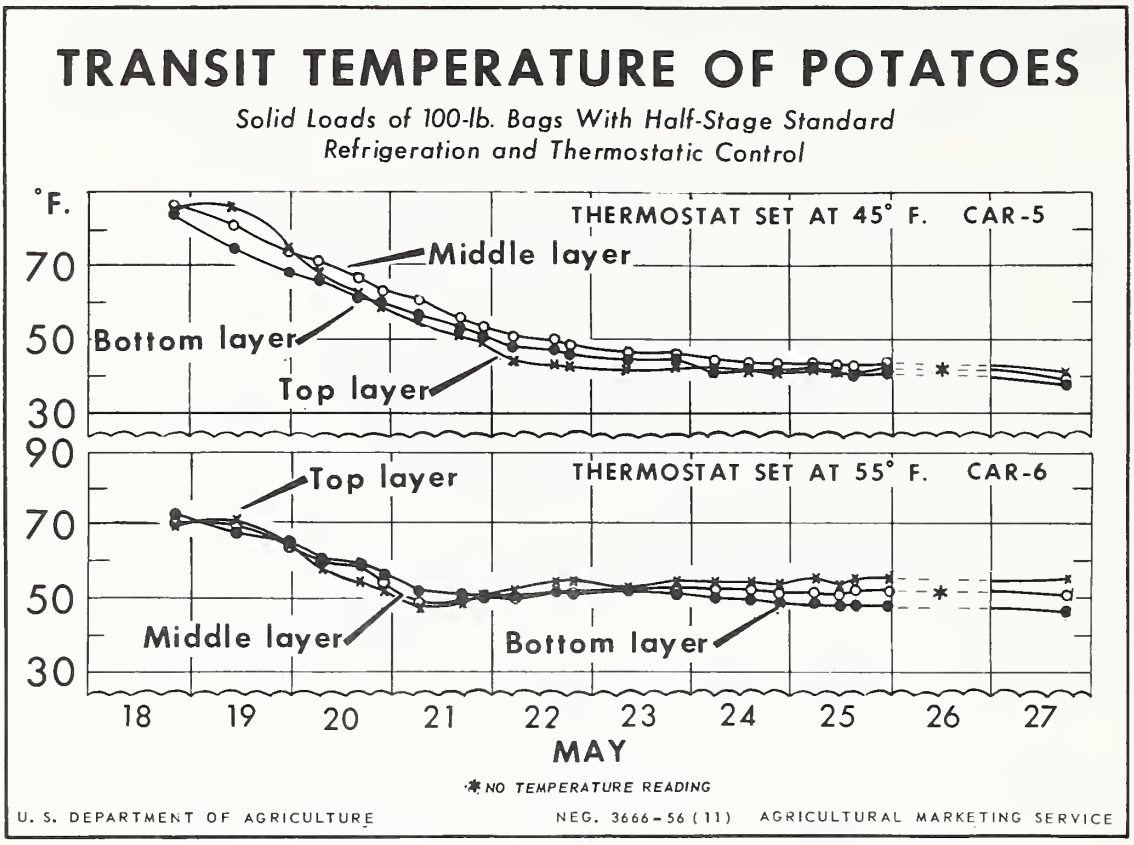

Figure 4.

Condition of Potatoes at the Market

Condition of the potatoes in the test samples is shown in table 4. For the most part, transit temperatures were favorable in all cars for periderm formation and suberization of skinned potatoes regardless of the shipping container, but varied enough to affect the degree of healing. Poor healing and excessive browning observed at the end of the holding period generally occurred in the samples that cooled relatively fast in transit to temperatures below 55° F. Good healing and acceptable color were evident in the samples that cooled more slowly and remained above 55° in transit. Most of the deterioration from browning occurred after the potatoes were removed from the car.

The potatoes shipped in cartons had the best appearance after holding at the market. Those shipped in paper bags and in regular burlap bags showed more browning but were acceptable commercially and would sell without discount.

Weight loss in test samples ranged from 1.8 percent to 4.5 percent during the transit period. The loss in weight in transit was slightly more in cartons than in the other containers, possibly because of moisture absorption by the fiberboard. However, subsequent loss of moisture from the potatoes during the holding period was less in the samples shipped in cartons, indicating favorable conditions in transit for suberization of skinned potatoes.

Decay ranged from 0 to 3.7 percent in the test samples, but was of no consequence in the commercial shipments. Decay was slightly greater in cartons than in paper or regular burlap bags.

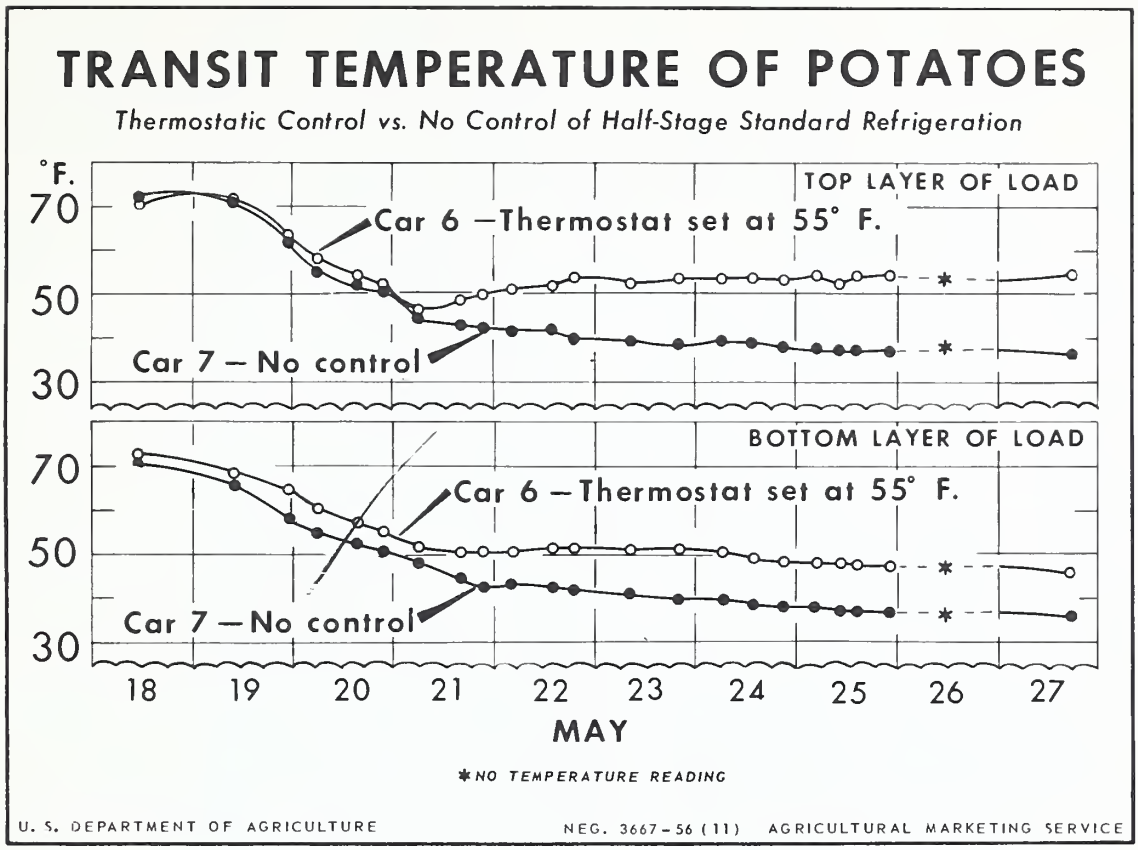

Figure 5.

Table 1.--Initial temperature, kind of load, and refrigeration for potatoes in the test cars

Test car No.	Car initials and number	Initial temperature	Number of containers in car	Type and size of container	Type of load[1]	Refrigeration service[2]
		°F.				
1.....	S.F.R.D.16657	84	700	50-lb. cartons	Channel	Standard refrigeration, half stage
2.....	S.F.R.D.16568	81	720	50-lb. cartons	Chimney	Standard refrigeration, half stage
3.....	S.F.R.D.18186	72	3,600	10-lb. bags	Solid	Initial ice at Bakersfield, re-ice at Belen and Corwith, half stage
4.....	S.F.R.D.18143	74	3,600	10-lb. bags	Solid	Standard refrigeration, half stage
5[3]....	S.F.R.D.16479	86	360	100-lb. bags	Solid	Standard refrigeration, half stage, thermostat set at 45° F.
6[3]....	S.F.R.D.16555	72	360	100-lb. bags	Solid	Standard refrigeration, half stage, thermostat set at 55° F.
7.....	S.F.R.D.16517	71	360	100-lb. bags	Solid	Standard refrigeration, half stage
8.....	S.F.R.D.16346	85	360	100-lb. bags	Solid	Initial ice at Bakersfield, re-ice at Needles and Argentine, half stage

[1] Through loads with no car strips or center brace.
[2] "Dry car" loading (no ice), standard ventilation to Bakersfield; initial ice Bakersfield, vents closed, fans on, Bakersfield to destination.
[3] Containing experimental equipment for thermostatic control of refrigeration.

Table 2.--Trip log of test cars

Date	Station	Arrival	Departure	Delays		Outside temperature[1]
				At station	Enroute	
May				Hrs. Min.	Hrs. Min.	° F.
18...	California loading points					98 (Max.)
19...	Bakersfield, Calif.....					57 (Min.)
19...	Bakersfield, Calif.....		3:40 p.m.(P.s.t.)	- -	2 - 21	87 (Max.)
	Barstow, Calif.....	11:30 p.m.	12:50 a.m.	1 - 20	0 - 10	68
20...	Enroute.....					57 (Min.)
20...	Needles, Calif.....	6:00 a.m.(P.s.t.)	9:20 a.m.(M.s.t.)	2 - 20	0 - 0	73
	Seligman, Ariz.....	3:42 p.m.	4:25 p.m.	0 - 43	0 - 12	80
	Enroute.....					86 (Max.)
	Winslow, Ariz.....	9:43 p.m.	11:20 p.m.	1 - 37	0 - 0	67
21...	Gallup, N. Mex.....	2:21 a.m.	2:35 a.m.	0 - 14	0 - 10	48 (Min.)
	Belen, N. Mex.....	6:15 a.m.	9:20 a.m.	3 - 5	0 - 7	70
	Vaughn, N. Mex.....	12:25 p.m.	12:50 p.m.	0 - 25	0 - 14	95 (Max.)
	Clovis, N. Mex.....	4:05 p.m.(M.s.t.)	6:39 p.m.(C.s.t.)	1 - 34	0 - 0	90
	Amarillo, Tex.....	9:05 p.m.	10:43 p.m.	1 - 38	1 - 2	76
22...	Canadian, Tex.....	12:45 a.m.	no stop			67 (Min.)
	Waynoka, Okla.....	4:40 a.m.	7:10 a.m.	2 - 30	0 - 10	70
	Wellington, Kans.....	10:05 a.m.	11:10 a.m.	1 - 5	0 - 0	--
	Emporia, Kans.....	2:30 p.m.	3:00 p.m.	0 - 30	0 - 9	97 (Max.)
	Argentine, Kans.....	6:20 p.m.	11:40 p.m.	5 - 20	0 - 5	88
23...	Marceline, Mo.....	3:45 a.m.	5:25 a.m.	1 - 40	0 - 12	57 (Min.)
	Shopton, Iowa.....	8:40 a.m.	9:49 a.m.	1 - 09	0 - 14	62
	Chillicothe, Ill.....	1:25 p.m.	2:30 p.m.	1 - 5	0 - 50	65 (Max.)
	Corwith, Ill.....	7:45 p.m.	4:15 a.m.	8 - 30	1 - 30	45
	Enroute.....					40 (Min.)
24...	Chicago, Ill.....	6:45 a.m.	9:45 a.m.	3 - 0	0 - 0	48
	Dalton, Ill.....	10:23 a.m.	11:00 a.m.	0 - 37	0 - 6	--
	Logansport, Ind.....	1:25 p.m.(C.s.t.)	4:05 p.m.(E.s.t.)	1 - 40	0 - 0	66
	Enroute.....					68 (Max.)
	Columbus, Ohio.....	9:20 p.m.	9:51 p.m.	0 - 31	0 - 40	50
25...	Pitcairn, Pa.....	4:20 a.m.	5:45 a.m.	1 - 25	0 - 0	34
	Altoona, Pa.....	8:40 a.m.	9:34 a.m.	0 - 54	0 - 0	32 (Min.)
	Huntington, Pa.....	10:35 a.m.	11:55 a.m.	1 - 20	0 - 0	68
	Enola, Pa.....	2:00 p.m.	4:17 p.m.	2 - 17	0 - 15	68
	Enroute.....					71 (Max.)
	Jersey City, N. J.....	9:00 p.m.	--	- -	- -	68

[1] At arrival at stations and daily minimum and maximum enroute.

Table 3.--Ice supply and estimated meltage in test cars

Station	Date	Time	Quantity of ice put in test car No.--							
			1	2	3	4	5[1]	6[1]	7	8
	May		Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Bakersfield, Calif.....	19	1:20 p.m.	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Needles, Calif.....	20	7:30 a.m.	3,600	3,900	--	3,300	4,200	3,300	3,900	3,600
Belen, New Mexico.....	21	8:00 a.m.	3,000	3,600	6,000	3,300	4,500	3,000	3,000	--
Waynoka, Oklahoma.....	22	5:25 a.m.	2,400	2,400	--	1,500	2,100	1,500	1,800	--
Argentine, Kans.....	22	8:35 p.m.	1,800	1,800	--	1,800	2,100	1,500	2,100	6,000
Corwith, Ill.....	23	9:10 p.m.	2,400	2,400	6,000	3,000	2,600	1,600	2,400	--
Huntington, Pa.....	25	11:30 a.m.	3,100	2,600	--	2,600	2,300	1,700	2,600	--
Total ice supplied.....			22,300	22,700	18,000	21,500	23,800	18,600	21,800	15,600
Ice remaining--Jersey City..	25	11:00 p.m.	5,200	5,200	3,300	5,200	5,000	5,400	5,000	450
Total ice melted.....			17,100	17,500	14,700	16,300	18,800	13,200	16,800	15,150

[1] Containing thermostatic equipment.

Table 4.--Transit temperatures and condition of potatoes in test samples, at arrival and after holding 7 days at the market

Car No.	Type of container	Location in load[1]	Transit temperature			Decay at arrival[2]	Weight loss		Percentage of potatoes with surface browning as indicated[3]						Appearance of sound tubers	
									At arrival			After holding				
			Initial	Average	Time above 55° F.		During transit	During holding	None to slight	Moderate	Severe	None to slight	Moderate	Severe	At arrival	After holding
			° F.	° F.	Days	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent		
1...	Carton...	TD	85	59	4	2.7	3.1	1.5	97.3	2.7	0	87.0	11.6	1.4	Good....	Good
	....do...	MD	85	64	5 1/2	3.7	3.3	1.3	97.8	2.2	0	97.1	2.9	0	....do..	Do.
2...	....do...	TD	78	50	2 1/4	1.6	3.5	1.7	96.8	3.2	0	87.2	11.2	1.6	....do..	Do.
	....do...	MD	86	57	3 1/2	3.5	4.5	1.3	94.4	4.9	.7	77.5	16.9	5.6	....do..	Do.
3...	10-lb.bag	TD	67	50	2 1/4	1.3	3.0	2.2	88.1	8.6	3.3	47.0	25.2	27.8	....do..	Poor
	....do...	MD	66	53	4	1.3	2.3	2.4	79.0	14.6	6.4	54.8	24.8	20.4	....do..	Fair
4...	....do...	TD	70	48	2	0	3.4	2.1	89.9	10.1	0	50.0	40.5	9.5	....do..	Do.
	....do...	MD	68	56	4	0	2.4	2.1	88.2	11.8	0	48.6	35.4	16.0	....do..	Do.
5...	100-lb. bag	TD	86	51	2 1/4	2.1	2.2	2.3	96.5	3.5	0	72.4	18.4	9.2	....do..	Do.
6...	....do...	TD	71	59	2 1/2	0	1.8	2.1	91.1	8.9	0	74.0	17.8	8.2	....do..	Do.
	....do...	BB	72	52	2 1/2	1.4	1.8	2.4	97.9	1.4	.7	76.0	18.5	5.5	....do..	Do.
7...	....do...	TD	72	49	2 3/4	0	2.5	2.4	88.7	11.3	0	67.5	21.2	11.3	....do..	Do.
	....do...	BB	70	43	1 1/2	0	2.5	2.3	71.4	23.3	5.3	47.3	25.6	27.1	Fair....	Poor
8...	....do...	TD	84	52	2	2.9	2.7	1.8	88.5	9.8	1.7	71.6	19.7	8.7	Good....	Fair

[1] TD--Top layer near doorway; MD--middle layer near doorway; BB--bottom layer near ice bunker.
[2] By count. No decay during holding period.
[3] Potatoes transferred to ventilated boxes for holding after arrival.